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ABSTRACT

An independent engineering evaluation was conducted of the Optical to Tactile Converter (Optacon), a reading aid for the blind which senses the contrast of printed text and coverts the information into a tactile presentation. The manufacturer's reply to the evaluation gives a general impression of the report, responds to specific suggestions for improvement, and makes recommendations for additional research. This document includes the manufacturer's letter of response, and it lists the reactions to each of the recommendations made in the various chapters of the evaluation report. (EMH)

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RESPONSE TO RECOMMENDATIONS IN THE FRANKLIN INSTITUTE RESEARCH LABORATORIES (FIRL) FINAL REPORT "ENGINEERING EVALUATION OF THE OPTACON. FINAL REPORT". (F-C3435).

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November 14, 1973

Dr. Max Mueller
Acting Director of Research
Office of Education
Bureau of Education for the Handicapped
7th and D St., SW
Washington, D. C. 20202

Dear Max:

In order to follow up on your recent suggestion and after careful study of the Franklin Institute Research Laboratories (FIRL) Final Report "Engineering Evaluation of the Optacon" Final Report F-C3435), we have compiled our response in this letter.

Overall, we are gratified with an independent assessment that the Optacon "is basically sound in its design", "is a viable tool for motivated individuals with unimpaired tactile capabilities", and is priced reasonably. We have put the best efforts of a talented group of people into the Optacon over the past several years, plus sticking our own necks out quite far, and are pleased to have this favorable recognition of the result.

Rather than dwell on too much detail, we will restrict our comments in this letter to four principal topics: 1) general impressions of the report, 2) response to suggested improvements, 3) comments on reliability studies, and 4) comments on major conclusions for further research.

1. General Impressions of the Report

We feel that, on the whole, the Engineering Evaluation was rather superficial. Given the turnover in personnel, the short time available for the compilation of such a report probably was not sufficient for FIRL to gain a deep understanding of all features of our engineering design. To cite two examples: our design permiting reversability of the retina module was intentional for very good reasons (as explained in the TSI Teaching Guidelines Manual), and the zoom lens system was completely misunderstood by FIRL.

Many valid suggestions for improvements were made in the FIRL report. However, independent action by TSI on most of these pre-dated the report. On the other hand, there are quite a few very serious design and manufacturing concerns that were overlooked by FIRL. For example, we have spent a great deal of effort in the design and alignment of the camera to assure a well-focused image over the zoom range -- a problem not recognized by FIRL. The stimulator array, which is really the key mechanical element of the system, was ignored in their mechanical evaluation which concentrated on the more straightforward components of the system.

Subjects were given the Optacon "cold" for the user evaluation, which resulted in some comments that principly reflect inadequate training. On the other hand, more effort and time appeared to go into the user evaluation than the other sections, and many of their suggestions were worthwhile.

2. Response to Suggested Improvements

Attached to this letter is a detailed response to the recommendations of each chapter of the FIRL report. The various suggestions were placed into four categories:

1) Valid-A: a good suggestion already independently implemented by TSI.

2) Valid-B: a valid suggestion not yet implemented. TSI will initiate appropriate changes. Some of these suggestions were previously considered by us.

3) Valid-C: a valid suggestion, but either considered too expensive and difficult to implement or of too marginal utility

4) Invalid: not deemed to be a valid suggestion for the reason stated.

In total, we classified 32 "Valid-A", 8 "Valid-B", 12 "Valid-C", and 34 "Invalid" suggestions. We will take action on the "Valid-B" items, all of which are minor improvements.

3. Comments on Reliability Studies

FIRL notes a discrepancy between the extremely good laboratory reliability and less satisfactory field reliability. We feel that this apparent contradiction can be explained by:

a) Probably higher field use than reported (noted on FIRL report)

b) Incomplete testing at FIRL.

We have been carefully monitoring field service problems, and feel that most have been of the type that would not become apparent in the standard "shake and bake" studies conducted at FIRL. Rather, they come about from repeated usage of the machine in a very rugged school environment. Problems of this nature include stripped thumbscrew, loose knob, loose zoom button. An electronic problem with the select gate integrated circuit (not noted by FIRL, and already corrected by TSI as described in TSI Quarterly Progress Report #7), precipitated a large number of failures in a teaching situation involving repeated use of the I/O connector.

When any trend of field failures has been noted, we have immediately taken action (e.g., better thumbscrews, torque knobs tighter, licktite zoom button) and agree that ultimate reliability will be "good to excellent" as noted by the FIRL report.

4. Comments on Major Conclusions for Further Research

Three major conclusions involving further research effort were drawn:

a) Further research at developing a one-hand Optacon -- although little of the data within the report leads to this conclusion, we certainly are in agreement. Further psychophysical study is needed to determine the merits of a one-hand unit. Relative merits of one-hand vs. two-hand operation need to be clarified. Engineering costs for a one-hand unit will be high.

b) Eliminate noise generated by bimorph stimulators -- we agree with this goal although a small minority of users find the noise troublesome. To determine whether a significant noise reduction is possible will require quite a bit of study and analysis. Total elimination of noise using bimorphs does not look feasible, and at the present time, we are fabricating a sound-damping box for users to try.

c) Convert output to Grade I Braille -- this suggestion would require automatic character recognition capability within the Optacon. Even if this capability could be satisfactorily engineered, cost and size of the Optacon would mushroom. In addition, the basic direct-translation philosophy of the Optacon would be violated, greatly reducing the range of usable printed materials.

Hopefully, the above comments on the FIRL report are useful. Naturally, we agree with the overall positive evaluation of the Optacon, even though we disagree with respect to various less-important details. We feel that the FIRL report was quite constructive, and that a reasonable job was done within the constraints. Our relationship with FIRL has been open and cordial, and we will be responding to some of their suggestions. On the whole, we feel the report

is most significant as an independent verification of the soundness of the Optacon engineering, rather than a source of any major contributions to improvements to Optacon cost, performance or reliability.

Sincerely,

James C. Bliss, Ph.D.
President

J. Stephen Brugler, Ph.D.
Vice President

JCB/JSB/jms

Enclosure

DETAILED RESPONSE TO RECOMMENDATIONS IN VARIOUS CHAPTERS
OF THE FIRL REPORT

Key to Responses: Valid-A -- Valid suggestion that has already been independently implemented

Valid-B -- Valid suggestion and TSI will initiate appropriate changes

Valid-C -- Valid suggestion, but too expensive, time consuming, or marginal to initiate at this time

Invalid -- Not deemed to be a valid suggestion

Chapter 2 -- User Evaluation

2.8 Summary and Recommendations

a. The threshold, intensity and zoom lens controls should have notches to enable the user to readily locate his settings. This would enable presetting for frequently read material. This would also aid recovery from accidental movement.

Valid-B -- good idea

b. Manufacture a model for left-handed operators by designing the front controls and case in a "mirror-image" of their present configurations.

Valid-A -- use by left-handed operators has not been a problem with proper training (see Teaching Guidelines Manual pp 52-53 and 62-63). We are presently evaluating various possible alternatives and we have built a prototype "mirror image" Optacon.

c. Increase length of all interconnecting cabling, including master/slave cables and cassette trainer cable.

Valid-C -- while in some situations longer cables could be marginally useful, the added expense (shielded cable would have to be used) does not seem to make it worthwhile.

d. Obtain cable connectors for the Visual Display and Cassette Trainer for self-guide and alignment as well as locking in place.

Valid-C -- although we agree a more easily keyed connector might have been chosen, we feel the investment of present training centers using the existing connector is so high that a change would create too much confusion and expense.

e. Improve camera and camera cable storage. Retractable cord and a quick disconnect fastener (instead of screw type) should be considered.

Valid-A -- a "camera holder" is being tried that facilitates camera stowage, plus providing a temporary storage location for the camera on top of the Optacon.

f. Include instructions for gripping the camera while reading. Emphasize "thumb-middle finger" grip.

Invalid -- no one camera holding technique seems clearly advantageous.

g. Key retina module so that it cannot be replaced upside-down.

Invalid -- the retina module was intentionally made reversible for specialized reading tasks and for insertion into various accessories as explained on pp 27 and 48 of the Teaching Guidelines Manual. We have never encountered any difficulties with this design and other evaluators have found this feature highly beneficial (e.g., San Diego Optacon Project).

h. Accentuate tactile indicator of camera aperture.

Valid-B -- this is a very marginal suggestion, since the present groove is quite tactile and no problem has been reported by teachers we have trained (see TSI Stage 2 Manual, pp 53 and 64). An accentuated, raised indicator would be much more expensive on the present machined part. However, this part will soon be molded, allowing a raised line to be easily added.

i. Supply adapter as optional accessory equipment to facilitate large print.

Valid-C -- we feel that an adaptor for reading small print would have greater utility. Our conclusion is supported by the American Foundation for the Blind Survey of over 100 Optacon users.

j. Supply all-weather carrying case.

Valid-B -- this has been one of the things we have wanted to do as time and funds permitted.

k. Design case flap to open over top of Optacon and to snap toward the rear of the unit to facilitate reading while the unit is still in the case.

Invalid -- we have never had any complaints or problems with the flap as it is, and cannot understand how it could affect reading performance unless FIRL evaluators were inadequately trained.

l. Increase range of adjustment of carrying strap.

Valid-B -- see "m" below.

m. Supply accessory pouch to house battery charger for portability.

Valid-B -- this suggestion and "l" above have been on our "things-to-do" list for quite a while. We want also to enable the pouch to handle the various accessories.

n. Improve vibrator quality control to insure that all pins are uniformly high.

Valid-A -- we are continually improving our stimulator array manufacturing process and quality control.

o. Design vibrators to eliminate possibility of shock (see Electrical Evaluation recommendations).

Valid-A -- this problem has been eliminated by a design change independently instituted by TSI.

p. Ruggedize the camera case. (See Optical & Mechanical Evaluation Recommendations).

Valid-C -- this has been a very minor problem and the expense required to make a significant change would have a doubtful benefit.

q. Design carrying case for easier removal of Optacon to avoid damage in handling.

Invalid -- trained users never remove the leather case.

r. Optional accessory equipment for locking unit to desk.

Invalid? -- this is a "soft" invalid, since we are not convinced that a lockable cradle is the best solution for the Optacon. However, we agree that a problem exists. As a first step, we are considering adding a prominent inscription on the instrument identifying it as a reading aid for the blind.

s. Emphasize to the user in operating instructions that he should expect battery depletion due to shelf storage. Also caution user regarding storage temperature limitations. Include optical element cleaning instructions.

Valid-B -- good idea to add battery depletion note to Owners Manual

Invalid -- temperature limitation is mentioned in Chapter 3 of the Owners Manual

Invalid -- we do not feel an owner should attempt to clean the optics.

t. Take a fresh look at the advisability of reading with more than one finger at a time. In addition, supply "what to do if Optacon doesn't" manual for minor repairs. All material should be available in Braille.

Valid-C -- a major research project to reconsider two-finger reading. Considerable research has already been done on this. The FIRL experiment described on pp 2 - 12 is invalid and thus does not conflict with the SRI research.

Invalid -- "what to do if Optacon doesn't" - type instructions already in Chapter 7 of Owners' Manual

Invalid -- material has already been prepared in braille and made available.

u, v. Provide special classrooms with proper desk size and locations. Rewire Optacon classrooms to accommodate equipment in convenient locations. Especially, provide grounding lug for 110 VAC lines. Program "downtime" into the course outline to accommodate repair time.

Valid suggestions not related to Optacon engineering.

w. Noise elimination (from bimorph stimulators) is a formidable problem unless alternate forms of tactile stimulation prove feasible (electrical shock, air puffs, etc.) but the noise could be reduced if the frequency of vibration was reduced. A study to determine the minimum frequency acceptable for legible reading should be undertaken. Skilled readers use much less "intensity" than do learners. By the same token, they may be just as adept at perceiving less "frequency."

Valid-C -- a long-standing feature. We are building an experimental noise-damping box as a possible Optacon accessory. Frequency reduction is not a valid suggestion because of the R-IC model and power consumption considerations.

Chapter 3 -- Optical Evaluation

3.7 Summary and Recommendations

a. The bayonet-type disconnect between the scanning head and the reading retina assembly should be modified so that the reading retina cannot be connected in the wrong orientation. This might be simply accomplished by locating the bayonet slots and mating pins unsymmetrically rather than 180° apart.

Invalid -- see comments under 2.8g.

b. Since the cable between the scanning head and the main Optacon unit is subject to considerable wear by flexing and rubbing, it is likely to require replacement. In the present manner of construction it appears that connection of a new cable at the end of the reading retina assembly would be a major operation involving the retina itself. The termination of the cable at the reading retina housing should be modified so that the risk of involving the retina in cable replacement is eliminated.

Invalid -- in the face of considerable abuse, and to our great pleasure, we have never experienced any failures of the camera cable. Solving this nonexistent problem would entail a great deal of design effort and expense, and probably lead to reduced reliability.

c. The lens cell consists of a hollow cylinder containing three optical elements held in place by a hollow end piece that is pressed into the end of the cell. It is recommended that this end piece be more positively attached to the lens cell. As a minimum a drop of Locktite or other adhesive agent should be applied at the flange to effect a bonding of these pieces.

Valid-A -- already fixed by a design change independently instituted by TSI.

d. The main aperture of the scanning head which contains the two illuminating lamps is milled out. For quantity production it is recommended that the design be modified so that this aperture can be stamped out of sheet material in order to effect a cost saving.

Invalid -- nonsense to expect any cost saving from this suggestion. In any case, the part will soon be injection molded.

e. The sheet metal cover of the scanning head is attached to the scanning head frame by four flat head screws. It is recommended that assembly time might be saved by reducing the number of these screws to two or even eliminating them by using a different method of attachment.

Invalid -- four screws are needed for mechanical integrity. Negative cost savings to change, considering the design effort involved.

Table 3-I -- Cost to Manufacture Per Unit in 1000 Quantity

Most of the cost estimates in this table are low by a factor of three or more.

Chapter 4 -- Electrical Evaluation

4.4 Recommendations

4.4.1 Immediate Changes

a. Shockproof bimorph pin. Either make the pins of insulating material or put insulating sleeves on the bimorphs.

Valid-A -- see 2.8-0.

b. Seek a better packaging yield on the retina chips. A 50% rejection rate due to packaging seems excessive.

Valid-A

c. Provide a field maintenance kit including extender cables.

Invalid -- all pc board components are accessible during normal operation without extender cables.

d. Redesign printed circuit boards to eliminate proximity of notes to circuits and sharp bends in circuits in order to increase production yield of circuits and to minimize potential hazards of shorts.

Valid-C -- although this suggestion is well taken, no actual production problems have been experienced due to the layout. A change now would be very expensive.

e. Redesign boards so all soldering is accomplished on one side of the board in order to accommodate fully automatic soldering.

Invalid -- we are presently negotiating with wave soldering machine vendors who feel that the present boards are adequate.

f. Eliminate 18 metal "stilts" connecting boards TSI-02001-001 and TSI-02001-007.

Invalid -- the stilts are for essential electrical intra-connection.

g. Use I.C. sockets throughout for ease of repair.

Invalid -- only one, very reliable, RTL integrated circuit has no socket. Its failure rate has been negligible.

h. Replace 24 pin flat pack I.C.'s with DIP configuration. Replace ceramic packages with plastic packs.

Invalid -- flat pack I.C. configuration is needed from stimulator array packaging requirements A change would contradict positive feature noted of multiple usage of this custom I.C.

Valid-A -- plastic packages are now used throughout.

i. Integrate the .1 Mfd capacitor "tacked" onto board TSI-02001-005 with printed circuit.

Valid-A.

4.4.2 Future Changes

a. Correct the "race" problem described in Section 4.1.4

Valid-C -- although we agree a potential problem exists, it has never occured in the over 500 Optacons manufactured to date.

b. Use a self-scanned camera chip to reduce the number of wires in the cable. It is understood that such a chip is planned for the next generation of Optacons.

Valid-C -- such chips were not available when the Optacon was designed.

c. Expend further effort to reduce the voltage requirement and complexity of the bimorph array. This subsystem currently contributes approximately one-third of the cost of the Optacon.

Valid-C -- since no promising approach is known for this, the redesign effort could be very expensive.

Chapter 5 -- Optacon Mechanical Evaluation

5.2 Anticipated Misuse

a. Housing should be fabricated of a high impact, energy absorbing plastic.

Invalid -- to tool for a plastic case would be very expensive and not necessarily more rugged. We feel an energy-absorbing carrying case would be a preferred solution.

b. The present Optacon is heavy. Reducing the weight of the Optacon would improve its ability to withstand falls.

Valid-C -- probably true, but much easier said than done.

c. The lens retained should be redesigned to provide a positive lock on the lens elements to withstand shock loading.

Valid-A.

d. A stronger adhesive should be used to cement the mirror to its mount. The present epoxy is not strong enough to withstand shock loading.

Valid-A

e. The camera cable should be reinforced. It should be spring-coiled to reduce its normal length and make it less prone to sharp bending and accidental snagging. A stronger cable strain relief at both the camera and Optacon ends is desired.

Invalid -- a spring-coiled cable would lead to severe operator tracking problems and would be another likely source of service problems.

Valid-A -- strain reliefs have been improved.

f. A removable cover plate should be designed for the camera to seal the optics against dust and moisture during storage and carrying.

Invalid -- this would be a loose part of marginal utility.

g. Rubber feet should be added to the chassis to lessen chances of sliding off a table or other surface.

Invalid -- Optacons are always utilized within their leather case which has a high coefficient of friction.

h. The leather carrying case has protrusions that are susceptible to accidental snagging on foreign objects. A smooth surfaced carrying case should be provided.

Invalid -- we are totally unconvinced that this is a problem area.

Chapter 6 -- Production Costs

6.2.1 Detailed Part Review

Specific recommendations are made in this section with respect to determining the best production process for 41 parts. Rather than a part-by-part breakdown, a brief summary follows:

9 parts -- no change recommended
19 parts -- change already independently implemented or being implemented by TSI (Valid-A)
11 parts -- recommendation not considered valid for many different reasons (Invalid)
2 parts -- recommendation valid and will be followed up by TSI (Valid-B).

The two new suggestions to be followed are:

#15 -- reduce tight tolerance on contact button

#33 -- mold strain relief clamp.

6.4 Conclusions and Recommendations

a. Molded plastic parts should be used in the camera and housing and metal stampings used wherever possible.

Valid-A -- for the most part, this has been done.

b. A major development effort to simplify circuitry and the stimulator array should be started.

Valid-C -- a major effort would be required beyond the financial resources of TSI considering the present quantity level of production.

c. The production rate should be increased to allow the use of more sophisticated tooling, fixturing and automated assembly devices.

Valid! This is not an engineering suggestion, but a Governmental policy suggestion with which we heartily agree!